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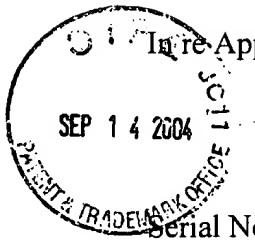

In re Application of:	THOMAS J. SONDERMAN SCOTT BUSHMAN CRAIG WILLIAM CHRISTIAN	Group Art Unit:	2125
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Serial No.:	09/851,905	Atty. Dkt.:	2000.044700/TT3229 CUSTOMER NO.: 23720
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For:	RUN-TO-RUN CONTROL METHOD FOR AUTOMATED CONTROL OF METAL DEPOSITION PROCESSES		

APPEAL BRIEF

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Commissioner for Patents
P.O. Box 1450
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Sir:

CERTIFICATE OF MAILING UNDER 37 C.F.R. § 1.8	
DATE OF DEPOSIT:	September 10, 2004

I hereby certify that this paper or fee is being deposited with the United States Postal Service with sufficient postage as "FIRST CLASS MAIL" addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Sharon V. Hart

Signature

On July 16, 2004, Appellants filed a Notice of Appeal in response to a Final Office Action dated March 2, 2004, issued in connection with the above-identified application, which was received and stamped by the USPTO Mailroom on July 19, 2004. In support of their appeal, Appellants hereby submit an original and two copies of this Appeal Brief to the Board of Patent Appeals and Interferences in response to the Final Office Action dated March 2, 2004.

The two-month date for filing this Appeal Brief is September 19, 2004. Since this Appeal Brief is being filed on September 10, 2004, this paper is believed to be timely filed.

Appellants hereby submit an original and two copies of this Appeal Brief to the Board of Patent Appeals and Interferences in response to the Final Office Action dated March 2, 2004.

The Director is authorized to deduct the fee for filing this Appeal Brief ($330.00) from Advanced Micro Devices, Inc. Deposit Account No. 01-0365/TT3229. Should any additional fees under 37 C.F.R. §§ 1.16 to 1.21 be required for any reason, the Commissioner is authorized to deduct said fees **from Advanced Micro Devices, Inc. Deposit Account No. 01-0365/TT3229.** In the event the monies in that account are insufficient, the Commissioner is authorized to withdraw funds from Williams, Morgan & Amerson, P.C. Deposit Account No. 50-0786/TT3229.

I. REAL PARTY IN INTEREST

The present application is owned by Advanced Micro Devices, Inc.

II. RELATED APPEALS AND INTERFERENCES

Appellants are not aware of any related appeals and/or interferences that might affect the outcome of this proceeding.

III. STATUS OF THE CLAIMS

Claims 1, 3-11, 13-21, 23-41- and 43-61 are pending in the application. Claims 1, 5, 6, 9-11, 16, 16, 19-21, 25, 26, 29-32, 35, 36, 39-41, 45, 46, 49-52, 55, 56, 59, and 60 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 4,166,783 (***Turner***). Claims 3, 4, 7, 8, 13, 14, 17, 18, 23, 24, 27, 28, 33, 34, 37, 38, 43, 44, 47, 48, 53, 54, 57, 58, and 61 stand rejected as being unpatentable over ***Turner*** in view of U.S. Patent No. 6,217,720 (***Sullivan***).

Claims 9, 10, 19, 20, 29, 30, 39, 40, 49, 50, 59, and 60 stand rejected as being unpatentable over ***Turner*** in view of claims 1, 2, 11, 12, 21, 22, 31, 32, 41, 42, 51, and 52.

The claims currently under consideration, *i.e.*, claims 1, 3-11, 13-21, 23-41- and 43-61, are attached as Appendix A.

IV. STATUS OF AMENDMENTS

There were no amendments after the final rejections.

V. SUMMARY OF THE INVENTION

Appellants' inventive methodologies are generally directed to a method comprising monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target, and modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time. The method also comprises applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness. *See*, p. 4, lines 15-20 of the Specification.

In another aspect of the present invention, a computer-readable, program storage device is provided, encoded with instructions that, when executed by a computer, perform a method, the method comprising monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target, and modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time. The method also comprises applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness. *See*, p. 4, line 21, through page 5, line 2 of the Specification.

In yet another aspect of the present invention, a computer programmed to perform a method is provided, the method comprising monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target, and modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time. The method also comprises applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness. *See*, p. 5, lines 3-9, of the Specification.

In another aspect of the present invention, a system is provided, the system comprising a tool monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target, and a computer modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time. The system also comprises a controller applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness. *See*, p. 5, lines 10-15, of the Specification.

In yet another aspect of the present invention, a device is provided, the device comprising means for monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target, and means for modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time. The device also comprises means for applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness. *See*, p. 5, lines 16-21, of the Specification.

As shown in Figure 1, a workpiece 100, such as a semiconducting substrate or wafer, having zero, one or more process layers and/or semiconductor devices such as a

metal-oxide-semiconductor (MOS) transistor disposed thereon, for example, is delivered to a metal deposition processing (MDP) step 105. In the metal deposition processing (MDP) step 105, metal deposition processing may be performed on the workpiece 100. *See,* p. 7, lines 15-19, of the Specification.

As shown in Figure 2, a dependence of a metal deposition rate on a sputter target life is illustrated. Sputter target consumption, measured by sputter target life (in arbitrary units), is plotted along the horizontal axis against deposition rates (in arbitrary units) plotted along the vertical axis. As described above, to the right of dotted line 200, generally the metal deposition rate 210 decreases as the sputter target life increases. The dependence of the metal deposition rate on the sputter target life may be determined by modeling, as described more fully below. *See,* p. 7, line 20, through p. 8, line 2, of the Specification.

As shown in Figure 3, the metal deposition processing (MDP) step 105 may communicate with a monitoring step 110 and other processing steps 140 via bidirectional connections through a system communications bus 160. As shown in Figure 3, the system communications bus 160 also provides communications between the metal deposition processing (MDP) step 105, the monitoring step 110 and other processing steps 140, and an Advanced Process Control (APC) system 120, more fully described below. *See,* p. 8, lines 3-8, of the Specification.

As shown in Figure 4, the workpiece 100 is sent from the metal deposition processing (MDP) step 105 and delivered to the monitoring step 110. In the monitoring step 110, one or more metal deposition processing (MDP) tool variables and/or one or more metal deposition processing (MDP) parameters during one or more metal deposition processing (MDP) runs may be monitored and/or measured. Examples of such tool variables and/or metal deposition

processing (MDP) parameters may comprise the degree of sputter target consumption (as measured by sputter target life), deposition plasma power, deposition time, temperature, pressure, gas flow, other parameters that may affect (for example, increase or decrease) the mean-free-path of the sputtered species, and the like. As shown in Figure 4, the monitoring step 110 may communicate with the metal deposition processing (MDP) step 105 via the system communications bus 160. As shown in Figure 4, the system communications bus 160 also provides communications between the metal deposition processing (MDP) step 105, the monitoring step 110, and the Advanced Process Control (APC) system 120, more fully described below. *See,* p. 8, lines 9-22, of the Specification.

As shown in Figure 5, the workpiece 100 is sent from the monitoring step 110 and delivered to the other processing steps 140. In the other processing steps 140, other processing steps may be performed on the workpiece 100 to produce the finished workpiece 100. In alternative illustrative embodiments, the workpiece 100 sent from the monitoring step 110 may be the finished workpiece 100, in which case, there may not be other processing steps 140. As shown in Figure 5, the other processing steps 140 may communicate with the monitoring step 110 via the system communications bus 160. As shown in Figure 5, the system communications bus 160 also provides communications between the monitoring step 110, the other processing steps 140, and the Advanced Process Control (APC) system 120, more fully described below. *See,* p. 8, line 23, through p. 9, line 7, of the Specification.

As shown in Figure 6, the monitored sensor data 115 is sent from the monitoring step 110 and delivered to the Advanced Process Control (APC) system 120. As shown in Figure 6, the Advanced Process Control (APC) system 120 may communicate with the monitoring step 110 via the system communications bus 160. Delivering the monitored sensor data 115 to the

Advanced Process Control (APC) system 120 produces an output signal 125. *See,* p. 9, lines 8-13, of the Specification.

As shown in Figure 7, the output signal 125 is sent from the Advanced Process Control (APC) system 120 and delivered to a metal deposition rate modeling with model inversion step 130. In the metal deposition rate modeling with model inversion step 130, the monitored sensor data 115 may be used in a metal deposition rate model, appropriate for the metal deposition processing (MDP) performed on the workpiece 100 in the metal deposition processing (MDP) step 105. Examples of such a metal deposition rate model, appropriate for metal deposition processing, may be provided by models empirically derived using MatLab®, Mathematica®, and the like. The use of the monitored sensor data 115 in a metal deposition rate model produces one or more metal deposition processing (MDP) recipe adjustments 145. *See,* p. 9, lines 14-22, of the Specification.

In various illustrative embodiments, a metal deposition rate model may be built. Such a metal deposition rate model may also be formed by monitoring one or more metal deposition processing (MDP) tool variables and/or one or more metal deposition processing (MDP) parameters during one or more metal deposition processing (MDP) runs. As described above, examples of such metal deposition processing (MDP) tool variables and/or metal deposition processing (MDP) parameters may comprise the degree of sputter target consumption (as measured by sputter target life), deposition plasma power, deposition time, temperature, pressure, gas flow, other parameters that may affect the mean-free-path of the sputtered species, and the like. In these various illustrative embodiments, building the metal deposition rate models may comprise fitting the collected processing data using at least one of polynomial curve fitting, least-squares fitting, polynomial least-squares fitting, non-polynomial least-squares fitting,

weighted least-squares fitting, weighted polynomial least-squares fitting, weighted non-polynomial least-squares fitting, and the like, as described more fully below. *See,* p. 9, line 23, through p. 10, line 11, of the Specification.

In various illustrative embodiments, the metal deposition rate model may incorporate model inversion capability. For example, the dependence of the deposition rate on the deposition plasma power, deposition time, and/or other variables may be adequately represented by: *deposition rate* = *f*(*deposition plasma power*, *deposition time*, ...). By inverting the model, the deposition plasma power and/or the deposition time that would be appropriate for a desired deposition rate may be determined. The deposition rate and the thickness of the metal layer may be related by: *thickness* = (*deposition rate*)(*deposition time*). Consequently, a deposited metal layer may be formed to have a desired thickness by inverting the deposition rate model, and choosing the deposition plasma power and/or the deposition time that would be appropriate for the desired deposition rate and, hence, the desired thickness. *See,* p. 10, lines 12-22, of the Specification.

For example, the dependence of the deposition rate on the deposition plasma power and the deposition time may be adequately represented by: $t = F(f,T) = f^{\alpha}T^{\beta}$, where the deposition rate is *t*, the deposition plasma power is *f*, the deposition time is *T*, and α and β are exponents, determined by fitting measured data points, as described more fully below. The desired thickness θ of the metal layer may be given by: $\theta = tT = F(f,T)T = f^{\alpha}T^{\beta+1}$, for example. The variation in the deposition rate with variations in the deposition plasma power and the deposition time may be adequately represented by: $\delta t = \alpha f^{\alpha-1}T^{\beta}\delta f + \beta f^{\alpha}T^{\beta-1}\delta T$, for example. A deposited metal layer may be formed to have a desired thickness θ by inverting the deposition rate model, $t^{1/\alpha} = T^{\beta/\alpha}f$ and $t^{1/\beta} = f^{\alpha/\beta}T$, and choosing the deposition plasma power *f* ($f = \theta^{1/\alpha}T^{-(\beta+1)/\alpha}$)

and/or the deposition time T ($T = \theta^{1/(\beta+1)} f^{-\alpha/(\beta+1)}$) that would be appropriate for the desired deposition rate t, and, hence, the desired thickness θ. *See,* p. 10, line 23, through p. 11, line 9, of the Specification.

The metal deposition rate modeling of the monitored sensor data 115 in the metal deposition rate modeling with model inversion step 130, may be used to alert an engineer of the need to adjust the processing performed in any of the processing steps, such as the metal deposition processing (MDP) step 105 and/or the other processing steps 140. The engineer may also alter and/or adjust, for example, the setpoints for the metal deposition processing (MDP) performed in the metal deposition processing (MDP) step 105, and/or the metal deposition processing (MDP) tool variable(s) and/or metal deposition processing (MDP) parameter(s) monitored and/or measured in the monitoring step 110. *See,* p. 11, lines 10-17, of the Specification.

As shown in Figure 8, a feedback control signal 135 may be sent from the metal deposition rate modeling with model inversion step 130 to the metal deposition processing (MDP) step 105 to adjust the metal deposition processing (MDP) performed in the metal deposition processing (MDP) step 105. For example, a deposited metal layer may be formed to have a desired thickness by inverting the deposition rate model, and choosing the deposition plasma power and/or the deposition time that would be appropriate for the desired deposition rate and, hence, the desired thickness. In various alternative illustrative embodiments, the feedback control signal 135 may be sent from the metal deposition rate modeling with model inversion step 130 to any of the other processing steps 140 to adjust the processing performed in any of the other processing steps 140, for example, via the system communications bus 160 that provides communications between the metal deposition processing (MDP) step 105, the monitoring

step 110, the other processing steps 140, and the Advanced Process Control (APC) system 120, more fully described below. *See,* p. 11, line 18, through p. 12, line 6, of the Specification.

As shown in Figure 9, in addition to, and/or instead of, the feedback control signal 135, the one or more metal deposition processing (MDP) recipe adjustments 145, and/or an entire appropriate recipe based upon this analysis, may be sent from the metal deposition rate modeling with model inversion step 130 to a metal deposition processing (MDP) process change and control step 150. In the metal deposition processing (MDP) process change and control step 150, the one or more metal deposition processing (MDP) recipe adjustments 145 may be used in a high-level supervisory control loop. Thereafter, as shown in Figure 10, a feedback control signal 155 may be sent from the metal deposition processing (MDP) process change and control step 150 to the metal deposition processing (MDP) step 105 to adjust the metal deposition processing (MDP) performed in the metal deposition processing (MDP) step 105. For example, a deposited metal layer may be formed to have a desired thickness by inverting the deposition rate model, and choosing the deposition plasma power and/or the deposition time that would be appropriate for the desired deposition rate and, hence, the desired thickness. In various alternative illustrative embodiments, the feedback control signal 155 may be sent from the metal deposition processing (MDP) process change and control step 150 to any of the other processing steps 140 to adjust the processing performed in any of the other processing steps 140, for example, via the system communications bus 160 that provides communications between the metal deposition processing (MDP) step 105, the monitoring step 110, the other processing steps 140, and the Advanced Process Control (APC) system 120, more fully described below. *See,* p. 12, line 7, through p. 13, line 2, of the Specification.

In various illustrative embodiments, the engineer may be provided with advanced process data monitoring capabilities, such as the ability to provide historical parametric data in a user-friendly format, as well as event logging, real-time graphical display of both current processing parameters and the processing parameters of the entire run, and remote, *i.e.*, local site and worldwide, monitoring. These capabilities may engender more optimal control of critical processing parameters, such as throughput accuracy, stability and repeatability, processing temperatures, mechanical tool parameters, and the like. This more optimal control of critical processing parameters reduces this variability. This reduction in variability manifests itself as fewer within-run disparities, fewer run-to-run disparities and fewer tool-to-tool disparities. This reduction in the number of these disparities that can propagate means fewer deviations in product quality and performance. In such an illustrative embodiment of a method of manufacturing according to the present invention, a monitoring and diagnostics system may be provided that monitors this variability and optimizes control of critical parameters. *See,* p. 13, lines 3-16, of the Specification.

Figure 11 illustrates one particular embodiment of a method 1100 practiced in accordance with the present invention. Figure 12 illustrates one particular apparatus 1200 with which the method 1100 may be practiced. For the sake of clarity, and to further an understanding of the invention, the method 1100 shall be disclosed in the context of the apparatus 1200. However, the invention is not so limited and admits wide variation, as is discussed further below. *See,* p. 13, lines 17-22, of the Specification.

Referring now to both Figures 11 and 12, a batch or lot of workpieces or wafers 1205 is being processed through a metal deposition processing (MDP) tool 1210. The metal deposition processing (MDP) tool 1210 may be any metal deposition processing (MDP) tool known to the

art, provided it comprises the requisite control capabilities. The metal deposition processing (MDP) tool 1210 comprises a metal deposition processing (MDP) tool controller 1215 for this purpose. The nature and function of the metal deposition processing (MDP) tool controller 1215 will be implementation specific. *See,* p. 13, line 23, through p. 14, line 4, of the Specification.

For instance, the metal deposition processing (MDP) tool controller 1215 may control metal deposition processing (MDP) control input parameters such as metal deposition processing (MDP) recipe control input parameters and/or setpoints. Four workpieces 1205 are shown in Figure 12, but the lot of workpieces or wafers, *i.e.*, the "wafer lot," may be any practicable number of wafers from one to any finite number. *See,* p. 14, lines 5-9, of the Specification.

The method 1100 begins, as set forth in box 1120, by monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing (MDP) performed on the workpiece 1205 in the metal deposition processing (MDP) tool 1210. The nature, identity, and measurement of characteristic parameters, such as deposition plasma power and/or deposition time and/or sputter target life, will be largely implementation specific and even tool specific. For instance, capabilities for monitoring process parameters vary, to some degree, from tool to tool. Greater sensing capabilities may permit wider latitude in the characteristic parameters that are identified and measured and the manner in which this is done. Conversely, lesser sensing capabilities may restrict this latitude. In turn, the metal deposition processing (MDP) control input parameters such as the metal deposition processing (MDP) recipe control input parameters and/or the setpoints for deposition plasma power and/or deposition time and/or flow rates of ambients (argon, Ar, for example) and/or chuck temperature and/or heat exchange temperature (for example, keeping one or more workpieces at approximately constant temperature, if possible) may directly affect the thickness of metal layers

deposited on the workpiece 1205 and/or sputter target life. *See,* p. 14, lines 1-24, of the Specification.

Turning to Figure 12, in this particular embodiment, the metal deposition processing (MDP) process characteristic parameters are measured and/or monitored by tool sensors (not shown). The outputs of these tool sensors are transmitted to a computer system 1230 over a line 1220. The computer system 1230 analyzes these sensor outputs to identify the characteristic parameters. *See,* p. 15, lines 1-5, of the Specification.

Returning, to Figure 11, once the characteristic parameters are identified and measured, the method 1100 proceeds by modeling a dependence of the deposition rate on the deposition plasma power and/or the deposition time using a metal deposition rate model, as set forth in box 1130. As described above, examples of such a metal deposition rate model, appropriate for metal deposition processing, may be provided by models empirically derived using MatLab®, Mathematica®, and the like. The computer system 1230 in Figure 12 is, in this particular embodiment, programmed to model the characteristic parameter(s). The manner in which this modeling occurs will be implementation specific. *See,* p. 15, lines 6-13, of the Specification.

In the embodiment of Figure 12, a database 1235 stores a plurality of models that might potentially be applied, depending upon which characteristic parameter is measured. This particular embodiment, therefore, requires some *a priori* knowledge of the characteristic parameters that might be measured. The computer system 1230 then extracts an appropriate model from the database 1235 of potential models to apply to the measured characteristic parameters. If the database 1235 does not include an appropriate model, then the characteristic parameter may be ignored, or the computer system 1230 may attempt to develop one, if so programmed. The database 1235 may be stored on any kind of computer-readable, program

storage medium, such as an optical disk 1240, a floppy disk 1245, or a hard disk drive (not shown) of the computer system 1230. The database 1235 may also be stored on a separate computer system (not shown) that interfaces with the computer system 1230. *See,* p. 15, lines 14-25, of the Specification.

Modeling of the measured characteristic parameter may be implemented differently in alternative embodiments. For instance, the computer system 1230 may be programmed using some form of artificial intelligence to analyze the sensor outputs and controller inputs to develop a model on-the-fly in a real-time implementation. This approach might be a useful adjunct to the embodiment illustrated in Figure 12, and discussed above, where characteristic parameters are measured and identified for which the database 1235 has no appropriate model. *See,* p. 16, lines 1-7, of the Specification.

The method 1100 of Figure 11 then proceeds by applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness, as set forth in box 1140. Depending on the implementation, applying the model may yield either a new value for a metal deposition processing (MDP) control input parameter or a correction to an existing metal deposition processing (MDP) control input parameter. In various illustrative embodiments, a multiplicity of control input recipes may be stored and an appropriate one of these may be selected based upon one or more of the determined parameters. The new metal deposition processing (MDP) control input is then formulated from the value yielded by the model and is transmitted to the metal deposition processing (MDP) tool controller 1215 over the line 1220. The metal deposition processing (MDP) tool controller 1215 then controls subsequent metal deposition processing (MDP) process operations in accordance with the new metal deposition processing (MDP) control inputs. *See,* p. 16, lines 8-19, of the Specification.

Some alternative embodiments may employ a form of feedback to improve the modeling of characteristic parameters. The implementation of this feedback is dependent on several disparate facts, including the tool's sensing capabilities and economics. One technique for doing this would be to monitor at least one effect of the model's implementation and update the model based on the effect(s) monitored. The update may also depend on the model. For instance, a linear model may require a different update than would a non-linear model, all other factors being the same. *See,* p. 7, line 20, through p. 17, line 2, of the Specification.

As is evident from the discussion above, some features of the present invention may be implemented in software. For instance, the acts set forth in the boxes 1120-1140 in Figure 11 are, in the illustrated embodiment, software-implemented, in whole or in part. Thus, some features of the present invention are implemented as instructions encoded on a computer-readable, program storage medium. The program storage medium may be of any type suitable to the particular implementation. However, the program storage medium will typically be magnetic, such as the floppy disk 1245 or the computer 1230 hard disk drive (not shown), or optical, such as the optical disk 1240. When these instructions are executed by a computer, they perform the disclosed functions. The computer may be a desktop computer, such as the computer 1230. However, the computer might alternatively be a processor embedded in the metal deposition processing (MDP) tool 1210. The computer might also be a laptop, a workstation, or a mainframe in various other embodiments. The scope of the invention is not limited by the type or nature of the program storage medium or computer with which embodiments of the invention might be implemented. *See,* p. 17, lines 3-16, of the Specification.

Thus, some portions of the detailed descriptions herein are, or may be, presented in terms of algorithms, functions, techniques, and/or processes. These terms enable those skilled in the art

most effectively to convey the substance of their work to others skilled in the art. These terms are here, and are generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electromagnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. *See,* p. 17, lines 17-23, of the Specification.

It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, and the like. All of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities and actions. Unless specifically stated otherwise, or as may be apparent from the discussion, terms such as "processing," "computing," "calculating," "determining," "displaying," and the like, used herein refer to the action(s) and processes of a computer system, or similar electronic and/or mechanical computing device, that manipulates and transforms data, represented as physical (electromagnetic) quantities within the computer system's registers and/or memories, into other data similarly represented as physical quantities within the computer system's memories and/or registers and/or other such information storage, transmission and/or display devices. *See,* p. 17, line 24, through p. 18, line 10, of the Specification.

Construction of an Illustrative Apparatus. An exemplary embodiment 1300 of the apparatus 1200 in Figure 12 is illustrated in Figures 13-14, in which the apparatus 1300 comprises a portion of an **A**dvanced **P**rocess **C**ontrol ("APC") system. Figures 13-14 are conceptualized, structural and functional block diagrams, respectively, of the apparatus 1300. A set of processing steps is performed on a lot of workpieces 1305 on a metal deposition

processing (MDP) tool 1310. Because the apparatus 1300 is part of an Advanced Process Control (APC) system, the workpieces 1305 are processed on a run-to-run basis. Thus, process adjustments are made and held constant for the duration of a run, based on run-level measurements or averages. A "run" may be a lot, a batch of lots, or even an individual wafer. *See,* p. 18, lines 11-19, of the Specification.

In this particular embodiment, the workpieces 1305 are processed by the metal deposition processing (MDP) tool 1310 and various operations in the process are controlled by a plurality of metal deposition processing (MDP) control input signals on a line 1320 between the metal deposition processing (MDP) tool 1310 and a workstation 1330. Exemplary metal deposition processing (MDP) control inputs for this embodiment might include those for the setpoints for deposition plasma power, deposition time, temperature, pressure, gas flow, other parameters that may affect (for example, increase or decrease) the mean-free-path of the sputtered species, and the like. *See,* p. 18, line 20, through p. 19, line 2, of the Specification.

When a process step in the metal deposition processing (MDP) tool 1310 is concluded, the semiconductor workpieces 1305 being processed in the metal deposition processing (MDP) tool 1310 are examined at a review station 1317. The metal deposition processing (MDP) control inputs generally affect the characteristic parameters of the semiconductor workpieces 1305 measured at the review station 1317, and, hence, the variability and properties of the acts performed by the metal deposition processing (MDP) tool 1310 on the workpieces 1305. Once errors are determined from the examination after the run of a lot of workpieces 1305, the metal deposition processing (MDP) control inputs on the line 1320 are modified for a subsequent run of a lot of workpieces 1305. Modifying the control signals on the line 1320 is designed to improve the next processing performed by the metal deposition processing (MDP) tool 1310.

The modification is performed in accordance with one particular embodiment of the method 1100 set forth in Figure 11, as described more fully below. Once the relevant metal deposition processing (MDP) control input signals for the metal deposition processing (MDP) tool 1310 are updated, the metal deposition processing (MDP) control input signals with new settings are used for a subsequent run of semiconductor devices. *See,* p. 19, lines 3-18, of the Specification.

Referring now to both Figures 13 and 14, the metal deposition processing (MDP) tool 1310 communicates with a manufacturing framework comprising a network of processing modules. One such module is an Advanced Process Control (APC) system manager 1440 resident on the computer 1340. This network of processing modules constitutes the Advanced Process Control (APC) system. The metal deposition processing (MDP) tool 1310 generally comprises an equipment interface 1410 and a sensor interface 1415. A machine interface 1430 resides on the workstation 1330. The machine interface 1430 bridges the gap between the Advanced Process Control (APC) framework, *e.g.*, the Advanced Process Control (APC) system manager 1440, and the equipment interface 1410. Thus, the machine interface 1430 interfaces the metal deposition processing (MDP) tool 1310 with the Advanced Process Control (APC) framework and supports machine setup, activation, monitoring, and data collection. The sensor interface 1415 provides the appropriate interface environment to communicate with external sensors such as LabView® or other sensor bus-based data acquisition software. Both the machine interface 1430 and the sensor interface 1415 use a set of functionalities (such as a communication standard) to collect data to be used. The equipment interface 1410 and the sensor interface 1415 communicate over the line 1320 with the machine interface 1430 resident on the workstation 1330. *See,* p. 19, line 19, through p. 20, line 11, of the Specification.

More particularly, the machine interface 1430 receives commands, status events, and collected data from the equipment interface 1410 and forwards these as needed to other Advanced Process Control (APC) components and event channels. In turn, responses from Advanced Process Control (APC) components are received by the machine interface 1430 and rerouted to the equipment interface 1410. The machine interface 1430 also reformats and restructures messages and data as necessary. The machine interface 1430 supports the startup/shutdown procedures within the Advanced Process Control (APC) System Manager 1440. It also serves as an Advanced Process Control (APC) data collector, buffering data collected by the equipment interface 1410, and emitting appropriate data collection signals. *See,* p. 20, lines 12-21, of the Specification.

In the particular embodiment illustrated, the Advanced Process Control (APC) system is a factory-wide software system, but this is not necessary to the practice of the invention. The control strategies taught by the present invention can be applied to virtually any semiconductor metal deposition processing (MDP) tool on a factory floor. Indeed, the present invention may be simultaneously employed on multiple metal deposition processing (MDP) tools in the same factory or in the same fabrication process. The Advanced Process Control (APC) framework permits remote access and monitoring of the process performance. Furthermore, by utilizing the Advanced Process Control (APC) framework, data storage can be more convenient, more flexible, and less expensive than data storage on local drives. However, the present invention may be employed, in some alternative embodiments, on local drives. *See,* p. 20, line 22, through p. 21, line 7, of the Specification.

The illustrated embodiment deploys the present invention onto the Advanced Process Control (APC) framework utilizing a number of software components. In addition to components

within the Advanced Process Control (APC) framework, a computer script is written for each of the semiconductor metal deposition processing (MDP) tools involved in the control system. When a semiconductor metal deposition processing (MDP) tool in the control system is started in the semiconductor manufacturing fab, the semiconductor metal deposition processing (MDP) tool generally calls upon a script to initiate the action that is required by the metal deposition processing (MDP) tool controller. The control methods are generally defined and performed using these scripts. The development of these scripts can comprise a significant portion of the development of a control system. *See,* p. 21, lines 8-17, of the Specification.

In this particular embodiment, there are several separate software scripts that perform the tasks involved in controlling the metal deposition processing (MDP) operation. There is one script for the metal deposition processing (MDP) tool 1310, including the review station 1317 and the metal deposition processing (MDP) tool controller 1315. There is also a script to handle the actual data capture from the review station 1317 and another script that contains common procedures that can be referenced by any of the other scripts. There is also a script for the Advanced Process Control (APC) system manager 1440. The precise number of scripts, however, is implementation specific and alternative embodiments may use other numbers of scripts. *See,* p. 21, line 18, through p. 22, line 2, of the Specification.

Operation of an Illustrative Apparatus. Figure 15 illustrates one particular embodiment 1500 of the method 1100 in Figure 11. The method 1500 may be practiced with the apparatus 1300 illustrated in Figures 13-14, but the invention is not so limited. The method 1500 may be practiced with any apparatus that may perform the functions set forth in Figure 15. Furthermore, the method 1100 in Figure 11 may be practiced in embodiments alternative to the method 1500 in Figure 15. *See,* p. 22, lines 3-8, of the Specification.

Referring now to all of Figures 13-15, the method 1500 begins with processing a lot of workpieces 1305 through a metal deposition processing (MDP) tool, such as the metal deposition processing (MDP) tool 1310, as set forth in box 1510. In this particular embodiment, the metal deposition processing (MDP) tool 1310 has been initialized for processing by the Advanced Process Control (APC) system manager 1440 through the machine interface 1430 and the equipment interface 1410. In this particular embodiment, before the metal deposition processing (MDP) tool 1310 is run, the Advanced Process Control (APC) system manager script is called to initialize the metal deposition processing (MDP) tool 1310. At this step, the script records the identification number of the metal deposition processing (MDP) tool 1310 and the lot number of the workpieces 1305. The identification number is then stored against the lot number in a data store 1360. The rest of the script, such as the APCData call and the Setup and StartMachine calls, are formulated with blank or dummy data in order to force the machine to use default settings. *See,* p. 22, lines 9-21, of the Specification.

As part of this initialization, the initial setpoints for metal deposition processing (MDP) control are provided to the metal deposition processing (MDP) tool controller 1315 over the line 1320. These initial setpoints may be determined and implemented in any suitable manner known to the art. In the particular embodiment illustrated, metal deposition processing (MDP) controls are implemented by control threads. Each control thread acts like a separate controller and is differentiated by various process conditions. For metal deposition processing (MDP) control, the control threads are separated by a combination of different conditions. These conditions may include, for example, the semiconductor metal deposition processing (MDP) tool 1310 currently processing the wafer lot, the semiconductor product, the semiconductor manufacturing operation, and one or more of the semiconductor processing tools (not shown)

that previously processed the semiconductor wafer lot. *See,* p. 22, line 22, through p. 23, line 7, of the Specification.

Control threads are separated because different process conditions affect the metal deposition processing (MDP) error differently. By isolating each of the process conditions into its own corresponding control thread, the metal deposition processing (MDP) error can become a more accurate portrayal of the conditions in which a subsequent semiconductor wafer lot in the control thread will be processed. Since the error measurement is more relevant, changes to the metal deposition processing (MDP) control input signals based upon the error will be more appropriate. *See,* p. 23, lines 8-14, of the Specification.

The control thread for the metal deposition processing (MDP) control scheme depends upon the current metal deposition processing (MDP) tool, current operation, the product code for the current lot, and the identification number at a previous processing step. The first three parameters are generally found in the context information that is passed to the script from the metal deposition processing (MDP) tool 1310. The fourth parameter is generally stored when the lot is previously processed. Once all four parameters are defined, they are combined to form the control thread name; MDPP02_OPER01_PROD01_MDPP01 is an example of a control thread name. The control thread name is also stored in correspondence to the wafer lot number in the data store 1360. *See,* p. 23, lines 15-23, of the Specification.

Once the lot is associated with a control thread name, the initial settings for that control thread are generally retrieved from the data store 1360. There are at least two possibilities when the call is made for the information. One possibility is that there are no settings stored under the current control thread name. This can happen when the control thread is new, or if the information was lost or deleted. In these cases, the script initializes the control thread assuming

that there is no error associated with it and uses the target values of the metal deposition processing (MDP) as the metal deposition processing (MDP) control input settings. It is preferred that the controllers use the default machine settings as the initial settings. By assuming some settings, metal deposition processing (MDP) errors can be related back to the control settings to facilitate feedback control. *See,* p. 23, line 24, through p. 24, line 8, of the Specification.

Another possibility is that the initial settings are stored under the control thread name. In this case, one or more wafer lots have been processed under the same control thread name as the current wafer lot, and have also been measured for metal deposition processing (MDP) error using the review station 1317. When this information exists, the metal deposition processing (MDP) control input signal settings are retrieved from the data store 1360. These settings are then downloaded to the metal deposition processing (MDP) tool 1310. *See,* p. 24, lines 9-14, of the Specification.

The workpieces 1305 are processed through the metal deposition processing (MDP) tool 1310. This comprises, in the embodiment illustrated, subjecting the workpieces 1305 to a metal deposition process. The workpieces 1305 are measured on the review station 1317 after their metal deposition processing (MDP) on the metal deposition processing (MDP) tool 1310. The review station 1317 examines the workpieces 1305 after they are processed for a number of errors. The data generated by the instruments of the review station 1317 is passed to the machine interface 1430 via sensor interface 1415 and the line 1320. The review station script begins with a number of Advanced Process Control (APC) commands for the collection of data. The review station script then locks itself in place and activates a data available script. This script facilitates the actual transfer of the data from the review station 1317 to the Advanced Process Control

(APC) framework. Once the transfer is completed, the script exits and unlocks the review station script. The interaction with the review station 1317 is then generally complete. *See,* p. 24, line 15, through p. 25, line 2, of the Specification.

As will be appreciated by those skilled in the art having the benefit of this disclosure, the data generated by the review station 1317 should be preprocessed for use. Review stations, such as KLA review stations, provide the control algorithms for measuring the control error. Each of the error measurements, in this particular embodiment, corresponds to one of the metal deposition processing (MDP) control input signals on the line 1320 in a direct manner. Before the error can be utilized to correct the metal deposition processing (MDP) control input signal, a certain amount of preprocessing is generally completed. *See,* p. 25, lines 3-9, of the Specification.

For example, preprocessing may include outlier rejection. Outlier rejection is a gross error check ensuring that the received data is reasonable in light of the historical performance of the process. This procedure involves comparing each of the metal deposition processing (MDP) errors to its corresponding predetermined boundary parameter. In one embodiment, even if one of the predetermined boundaries is exceeded, the error data from the entire semiconductor wafer lot is generally rejected. *See,* p. 25, lines 10-15, of the Specification.

To determine the limits of the outlier rejection, thousands of actual semiconductor manufacturing fabrication ("fab") data points are collected. The standard deviation for each error parameter in this collection of data is then calculated. In one embodiment, for outlier rejection, nine times the standard deviation (both positive and negative) is generally chosen as the predetermined boundary. This was done primarily to ensure that only the points that are

significantly outside the normal operating conditions of the process are rejected. *See,* p. 25, lines 16-21, of the Specification.

Preprocessing may also smooth the data, which is also known as filtering. Filtering is important because the error measurements are subject to a certain amount of randomness, such that the error significantly deviates in value. Filtering the review station data results in a more accurate assessment of the error in the metal deposition processing (MDP) control input signal settings. In one embodiment, the metal deposition processing (MDP) control scheme utilizes a filtering procedure known as an **E**xponentially-**W**eighted **M**oving **A**verage ("EWMA") filter, although other filtering procedures can be utilized in this context. *See,* p. 25, line 22, through p. 26, line 3, of the Specification.

One embodiment for the EWMA filter is represented by Equation (1):

$$AVG_N = W * M_C + (1-W) * AVG_P \quad (1)$$

where

$AVG_N \equiv$ the new EWMA average;

$W \equiv$ a weight for the new average (AVG_N);

$M_C \equiv$ the current measurement; and

$AVG_P \equiv$ the previous EWMA average. *See,* p. 26, lines 11-15, of the Specification.

The weight is an adjustable parameter that can be used to control the amount of filtering and is generally between zero and one. The weight represents the confidence in the accuracy of the current data point. If the measurement is considered accurate, the weight should be close to one. If there were a significant amount of fluctuations in the process, then a number closer to zero would be appropriate. *See,* p. 26, lines 11-15, of the Specification.

In one embodiment, there are at least two techniques for utilizing the EWMA filtering process. The first technique uses the previous average, the weight, and the current measurement as described above. Among the advantages of utilizing the first implementation are ease of use and minimal data storage. One of the disadvantages of utilizing the first implementation is that this method generally does not retain much process information. Furthermore, the previous average calculated in this manner would be made up of every data point that preceded it, which may be undesirable. The second technique retains only some of the data and calculates the average from the raw data each time. *See,* p. 26, lines 16-23, of the Specification.

The manufacturing environment in the semiconductor manufacturing fab presents some unique challenges. The order that the semiconductor wafer lots are processed through an metal deposition processing (MDP) tool may not correspond to the order in which they are read on the review station. This could lead to the data points being added to the EWMA average out of sequence. Semiconductor wafer lots may be analyzed more than once to verify the error measurements. With no data retention, both readings would contribute to the EWMA average, which may be an undesirable characteristic. Furthermore, some of the control threads may have low volume, which may cause the previous average to be outdated such that it may not be able to accurately represent the error in the metal deposition processing (MDP) control input signal settings. *See,* p. 26, line 24, through p. 27, line 8, of the Specification.

The metal deposition processing (MDP) tool controller 1315, in this particular embodiment, uses limited storage of data to calculate the EWMA filtered error, *i.e.*, the first technique. Wafer lot data, including the lot number, the time the lot was processed, and the multiple error estimates, are stored in the data store 1360 under the control thread name. When a new set of data is collected, the stack of data is retrieved from data store 1360 and analyzed. The

lot number of the current lot being processed is compared to those in the stack. If the lot number matches any of the data present there, the error measurements are replaced. Otherwise, the data point is added to the current stack in chronological order, according to the time periods when the lots were processed. In one embodiment, any data point within the stack that is over 128 hours old is removed. Once the aforementioned steps are complete, the new filter average is calculated and stored to data store 1360. *See,* p. 27, lines 9-19, of the Specification.

Thus, the data is collected and preprocessed, and then processed to generate an estimate of the current errors in the metal deposition processing (MDP) control input signal settings. First, the data is passed to a compiled MatLab® plug-in that performs the outlier rejection criteria described above. The inputs to a plug-in interface are the multiple error measurements and an array containing boundary values. The return from the plug-in interface is a single toggle variable. A nonzero return denotes that it has failed the rejection criteria, otherwise the variable returns the default value of zero and the script continues to process. *See,* p. 27, line 20, through p. 28, line 2, of the Specification.

After the outlier rejection is completed, the data is passed to the EWMA filtering procedure. The controller data for the control thread name associated with the lot is retrieved, and all of the relevant operation upon the stack of lot data is carried out. This comprises replacing redundant data or removing older data. Once the data stack is adequately prepared, it is parsed into ascending time-ordered arrays that correspond to the error values. These arrays are fed into the EWMA plug-in along with an array of the parameter required for its execution. In one embodiment, the return from the plug-in is comprised of the six filtered error values. *See,* p. 28, lines 3-10, of the Specification.

Returning to Figure 15, data preprocessing comprises monitoring the target life of a sputter target to determine a deposition rate of a metal layer during metal deposition processing of the workpiece 1305 in the metal deposition processing (MDP) tool 1310 variables, as set forth in box 1520. Known, potential characteristic parameters, such as the target life of a sputter target, may be identified by characteristic data patterns or may be identified as known consequences of modifications to metal deposition processing (MDP) control. In turn, the metal deposition processing (MDP) control input parameters such as the metal deposition processing (MDP) recipe control input parameters and/or the setpoints for deposition plasma power and/or deposition time and/or flow rates of ambients and/or chuck temperature and/or heat exchange temperature may directly affect the sputter target life and/or the thickness of metal layers deposited on the workpiece 1205. *See,* p. 28, lines 11-21, of the Specification.

The next step in the control process is to calculate the new settings for the metal deposition processing (MDP) tool controller 1315 of the metal deposition processing (MDP) tool 1310. The previous settings for the control thread corresponding to the current wafer lot are retrieved from the data store 1360. This data is paired along with the current set of metal deposition processing (MDP) errors. The new settings are calculated by calling a compiled MatLab® plug-in. This application incorporates a number of inputs, performs calculations in a separate execution component, and returns a number of outputs to the main script. Generally, the inputs of the MatLab® plug-in are the metal deposition processing (MDP) control input signal settings, the review station 1317 errors, an array of parameters that are necessary for the control algorithm, and a currently unused flag error. The outputs of the MatLab® plug-in are the new controller settings, calculated in the plug-in according to the controller algorithm described above. *See,* p. 28, line 22, through p. 29, line 8, of the Specification.

A metal deposition processing (MDP) process engineer or a control engineer, who generally determines the actual form and extent of the control action, can set the parameters. They include the threshold values, maximum step sizes, controller weights, and target values. Once the new parameter settings are calculated, the script stores the setting in the data store 1360 such that the metal deposition processing (MDP) tool 1310 can retrieve them for the next wafer lot to be processed. The principles taught by the present invention can be implemented into other types of manufacturing frameworks. *See,* p. 29, lines 9-15, of the Specification.

Returning again to Figure 15, the calculation of new settings comprises, as set forth in box 1530, modeling the dependence of the deposition rate on the deposition plasma power and/or the deposition time characteristic parameter(s) using a metal deposition rate model. This modeling may be performed by the MatLab® plug-in. In this particular embodiment, only known, potential characteristic parameters are modeled and the models are stored in a database 1335 accessed by a machine interface 1430. The database 1335 may reside on the workstation 1330, as shown, or some other part of the Advanced Process Control (APC) framework. For instance, the models might be stored in the data store 1360 managed by the Advanced Process Control (APC) system manager 1440 in alternative embodiments. The model will generally be a mathematical model, *i.e.*, an equation describing how the change(s) in metal deposition processing (MDP) recipe control(s) affects the metal deposition processing (MDP) performance, and the like. The models described in various illustrative embodiments given above, and described more fully below, are examples of such models. As described above, examples of such metal deposition rate models, appropriate for metal deposition processing, may be provided by models empirically derived using MatLab®, Mathematica®, and the like. *See,* p. 29, line 16, through p. 30, line 6, of the Specification.

The particular model used will be implementation specific, depending upon the particular metal deposition processing (MDP) tool 1310 and the particular characteristic parameter(s) being modeled. Whether the relationship in the model is linear or non-linear will be dependent on the particular parameter(s) involved. *See,* p. 30, lines 7-10, of the Specification.

The new settings are then transmitted to and applied by the metal deposition processing (MDP) tool controller 1315. Thus, returning now to Figure 15, once the characteristic parameter(s) are modeled, the deposition rate model is applied to modify the metal deposition processing recipe parameter(s) to form the metal layer to have a desired thickness, described more fully above, as set forth in box 1540. In this particular embodiment, the machine interface 1430 retrieves the model from the database 1335, plugs in the respective value(s), and determines the necessary change(s) in the metal deposition processing (MDP) recipe control input parameter(s). The change is then communicated by the machine interface 1430 to the equipment interface 1410 over the line 1320. The equipment interface 1410 then implements the change. *See,* p. 30, lines 11-20, of the Specification.

The present embodiment furthermore provides that the models be updated. This comprises, as set forth in boxes 1550-1560 of Figure 15, monitoring the effect of modifying the metal deposition processing (MDP) recipe control input parameter(s) (box 1550) and updating the applied model(s) (box 1560) based on the effect(s) monitored. For instance, various aspects of the operation of the metal deposition processing (MDP) tool 1310 will change as the metal deposition processing (MDP) tool 1310 ages. By monitoring the effect of the metal deposition processing (MDP) recipe change(s) implemented as a result of the characteristic parameter measurement, the value(s) could be updated to yield improved performance. *See,* p. 30, line 21, through p. 31, line 4, of the Specification.

As noted above, this particular embodiment implements an Advanced Process Control (APC) system. Thus, changes are implemented "between" lots. The actions set forth in the boxes 1520-1560 are implemented after the current lot is processed and before the second lot is processed, as set forth in box 1570 of Figure 15. However, the invention is not so limited. Furthermore, as noted above, a lot may constitute any practicable number of wafers from one to several thousand (or practically any finite number). What constitutes a "lot" is implementation specific, and so the point of the fabrication process in which the updates occur will vary from implementation to implementation. *See,* p. 31, lines 5-12, of the Specification.

In various illustrative embodiments, the dependence of the deposition rate on the target life of the sputter target, the deposition plasma power, the deposition time, and the like, may be determined by modeling and/or fitting previously obtained metal deposition processing data. In these various illustrative embodiments, building the models may comprise fitting the collected processing data using at least one of polynomial curve fitting, least-squares fitting, polynomial least-squares fitting, non-polynomial least-squares fitting, weighted least-squares fitting, weighted polynomial least-squares fitting, and weighted non-polynomial least-squares fitting, and the like. *See,* p. 31, lines 13-20, of the Specification.

Any of the above-disclosed embodiments of a method according to the present invention enables the use of parametric measurements sent from measuring tools to make supervisory processing adjustments, either manually and/or automatically, to improve and/or better control the yield. Additionally, any of the above-disclosed embodiments of a method of manufacturing according to the present invention enables semiconductor device fabrication with increased device accuracy and precision, increased efficiency and increased device yield, enabling a streamlined and simplified process flow, thereby decreasing the complexity and lowering the

costs of the manufacturing process and increasing throughput. *See,* p. 48, lines 9-16, of the Specification.

Appellants' inventive methodologies are generally directed to a method comprising monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target, and modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time. The method also comprises applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness. *See,* p. 4, lines 15-20, of the Specification.

In another aspect of the present invention, a computer-readable, program storage device is provided, encoded with instructions that, when executed by a computer, perform a method, the method comprising monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target, and modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time. The method also comprises applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness. *See,* p. 4, line 21, through p. 5, line 2, of the Specification.

In yet another aspect of the present invention, a computer programmed to perform a method is provided, the method comprising monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target, and modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time. The method also comprises applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness. *See,* p. 5, lines 10-15, of the Specification.

In another aspect of the present invention, a system is provided, the system comprising a tool monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target, and a computer modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time. The system also comprises a controller applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness. *See,* p. 5, lines 16-21, of the Specification.

In yet another aspect of the present invention, a device is provided, the device comprising means for monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target, and means for modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time. The device also comprises means for applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness.

Of course, the present invention should not be considered as limited to the specifically disclosed embodiments discussed immediately above.

VI. ISSUE ON APPEAL

1. Whether claims 1, 5, 6, 9-11, 15, 16, 19-21, 25, 26, 29-32, 35, 36, 39-41, 45, 46, 49-52, 55, 56, 59, and 60 are anticipated by U.S. Patent No. 4,166,783 (***Turner***).

2. Whether claims 3, 4, 7, 8, 13, 14, 17, 18, 23, 24, 27, 28, 33, 34, 37, 38, 43, 44, 47, 48, 53, 54, 57, 58, and 61, are unpatentable over ***Turner*** in view of U.S. Patent No. 6,217,720 (***Sullivan***).

3. Whether claims 9, 10, 19, 20, 29, 30, 39, 40, 49, 50, 59, and 60 are unpatentable over ***Turner*** as applied to claims 1, 2, 11, 12, 21, 22, 31, 32, 41, 42, 51, and 52.

VII. GROUPING OF THE CLAIMS

Claims 1, 11, and 21 are grouped together (Group I), and stand or fall together; claims 3-8, 13-18, 23-28, 33-38, 43-48, and 53-58 are grouped together (Group II), and stand or fall together; claims 9-10, 19-20, 29-30, 39-40, 49-50, and 59-60 are grouped together (Group III); claims 31-32, 41, and 51-52 are grouped together (Group IV), and stand or fall together; and claim 61 is in its own group (Group V), and stands or falls alone.

VIII. ARGUMENT

A. Claims 1, 5, 6, 9-11, 15, 16, 19-21, 25, 26, 29-32, 35, 36, 39-41, 45, 46, 49-52, 55, 56, 69, and 60 Are Not Anticipated by *Turner*

The present invention is directed to modeling the dependence of the deposition rate on plasma power or the deposition time based upon the target life of the sputter target. This is in contrast with ***Turner*** since it does not disclose modeling the deposition rate at all. ***Turner*** discloses a sputtering system, in which the desired deposition rate information is inputted by an operator to calculate the required power (see col. 3, lines 30-34). ***Turner*** discloses that deposition rate sensors are not used to complete a feedback loop, but use the sputtering source itself. ***Turner*** discloses using the sputtering to allow for regulation and correction of a process (col. 3, lines 64-67). However, ***Turner*** does not disclose monitoring the consumption of a sputter target to determine a deposition rate, as called for by claims of the present invention.

Appellants assert that claims 1, 5, 6, 9-11, 15, 16, 19-21, 25, 26, 29-32, 35, 36, 39-41, 45, 46, 49-52, 55, 56, 69, and 60 are not anticipated by ***Turner***. In the Final Office Action dated March 2, 2004, the Examiner did not address the amendment provided in the preliminary amendment filed alongside the Request for Continuing Examination (RCE). Appellants respectfully assert that the Examiner was required to have addressed the amendments filed in the Preliminary Amendment that was filed alongside the RCE. Therefore, the Examiner erred in not addressing the amendments filed in the Preliminary Amendment. Furthermore Appellants respectfully assert that the amendments filed in the Preliminary Amendment place the claims in condition for allowance.

Appellants respectfully asserts that Examiner did not address the claim amendments relating to modeling the dependence of the deposition rate, which includes using the deposition sensor data for performing the modeling of the dependence of the deposition rate to a deposition plasma power or a deposition time based upon a target life of the sputter target, which is not disclosed by ***Turner***. In the Final Office Action dated March 2, 2004, in the "Response to Arguments" section on page 2, the Examiner stated that the Examiner had already addressed the arguments made by the Appellants in the response filed on January 26, 2004, and accordingly, the rejection was made final. However, Appellants respectfully asserts that the Examiner did not address the amendments to the claims, particularly the amendment described above. Therefore, Appellants respectfully requests that the Examiner withdraw the finality of the present application.

The Appellants respectfully asserts that ***Turner*** does not disclose or suggest all of the elements of the claims of the present invention. For example, the Examiner cites column 3, lines

22-32 of ***Turner*** to read upon the element of monitoring the consumption of the sputter target to determine a deposition rate, as called for by claims of the present invention. However, ***Turner*** merely discloses that the deposition rate, the power consumption, and the aging characteristics may be expressed as an empirically obtained function specific to the cathode material. The age of the cathode is expressed in kilowatt hours. *See* column 3, lines 23-32. However, this does not relate to consumption of a sputter target to the deposition rate and modeling the dependence on the deposition rate to the target life of the sputter target. Merely disclosing the age of the cathode does not relate to the target life of the sputter target as called for by claims of the present invention.

Furthermore, in the Final Office Action dated March 2, 2004, the Examiner makes an implication of deposition plasma power and target life from ***Turner***. However, this implication is not supported by neither the Examiner's arguments, nor by the disclosure of ***Turner***. The power consumption disclosed by ***Turner*** generally refers to the power dissipated by the excitation source, which is monitored by examining the current drawn from the cathode and the cathode-anode voltage (see col. 1, lines 42-47). ***Turner*** does not disclose modeling the dependence of the deposition rate to a deposition plasma power, and Appellants respectfully asserts that the Examiner does not offer evidence to imply the deposition plasma power. Appellants respectfully asserts that there is no disclosure or any evidence provided by the Examiner to make such an implication and it would be inappropriate in a rejection under 35 U.S.C. § 102. ***Turner*** discloses that the current drawn from the cathode supply is controlled in response to power dissipated in the plasma, the cumulative usage of the particular target, the pressure and the desired deposition rate. (See col. 3, lines 7-11). However, ***Turner*** does not disclose modeling these relationships. Furthermore, Turner does not disclose modeling based

upon a target life of the sputter target, as called for by claims of the present invention. Therefore, the claims of the present invention are allowable.

In the present and previous Office Actions, for example, in the Office Action dated October 28, 2003, the Examiner had asserted that that ***Turner*** does not actually use the deposition rate sensors, but still discloses them. Also, the Examiner cites the sputtering source in ***Turner***, which the Examiner asserts may be used to provide rate information to illustrate a prior art sensor. However, Appellants respectfully asserts that even though ***Turner*** may mention deposition rate monitors that are used to control the excitation source of the plasma discharge and/or the sputtering source, these disclosures are not enough to anticipate or suggest all of the elements of claim 1 of the present invention. For example, as explained in more detail below, ***Turner*** does not disclose modeling the dependence of the deposition rate on plasma power. As another example, ***Turner*** does not disclose modeling any parameters based upon target lives, as called for by claim 1 of the present invention. Although ***Turner*** refers to a deposition monitor, ***Turner*** does not disclose using the deposition monitor to perform any type of modeling. In fact, ***Turner*** discourages the use of the deposition monitor in contrast to the use of deposition sensor data to perform a modeling, as called for by the claims of the present invention. (Turner discloses that a deposition rate sensor is not used to complete the feedback loop of Turner, see col. 3, lines 64-65). Therefore, for at least the reasons cite above, all of the elements of claim 1 are not taught, disclosed, or suggested by ***Turner***, and therefore, are allowable.

Turner discloses a sputtering system, in which the desired deposition rate information is inputted by an operator to calculate the required power (see col. 3, lines 30-34). ***Turner*** discloses that deposition rate sensors are not used to complete a feedback loop, but use the

sputtering source itself. ***Turner*** discloses using the sputtering to allow for regulation and correction of a process (col. 3, lines 64-67). However, ***Turner*** does not disclose monitoring the consumption of a sputter target to determine a deposition rate, as called for by claim 1 of the present invention. ***Turner*** discloses using the power and duration of the sputtering source operation and calculating a percentage of normalized deposition rate.

Furthermore, claim 1 of the present invention calls for modeling the dependence of the deposition rate on plasma power or the deposition time based upon the target life of the sputter target. This is in contrast with ***Turner*** since it does not disclose modeling the deposition rate at all. The Examiner cites the chart in Figure 1 and implies that it refers to modeling of plasma power. Appellants respectfully disagree with this implication. Figure 1 merely plots a relationship between a percentage of normalized deposition rate and kilowatt-hours of operation of the cathode (see Figure 1 and col. 2, lines 35-44). This is provided to illustrate the deterioration of the deposition rate. However, this is not equivalent to modeling the dependence of the deposition on plasma power or the deposition time based upon the target life of the sputter target, since ***Turner*** merely demonstrates the deterioration of the deposition rate after a certain amount of kilowatt-hours.

Additionally, the Examiner equates aging of the cathode in use to "target lives," however, the "target lives" refer to the lives of the sputter targets (see col. 2, lines 10-13). Therefore, ***Turner*** does not call for modeling any parameters based upon target lives. Additionally, the Examiner states that the graph in Figure 1 plotting the percentage of normalized deposition rate versus the cathode operation (kilowatt-hours) can be used to imply a modeling of deposition rate to plasma power. However, the Examiner offers neither arguments nor evidence to support such

a conclusion, nor is there any evidence in ***Turner*** to support such an assertion. Therefore, ***Turner*** does not disclose the element of modeling the dependence of the deposition on plasma power or the deposition time based upon the target life of the sputter target, or using the model to modify a deposition process, as called for by claim 1 of the present invention.

Turner discloses using the desired rate specified by the operator, and using an equation in a loop to correct the power for the usage of a cathode used in the sputtering system (see col. 3, lines 32-38, and the equation on col. 3, line 27). ***Turner*** discloses that the duration of the cathode usage is then incremented, updating the kilowatt hours of use (see col. 3, lines 38-42). ***Turner*** corrects the current control of the cathode power supply and continues the loop for controlling the processing of a semiconductor wafer (see col. 3, lines 46-49). In contrast to ***Turner***, claim 1 calls for modeling the dependence of the deposition rate on the plasma power or deposition time based upon the target life, and using the model to modify the deposition processing to approach a desired thickness. Therefore, claim 1 is not taught, disclosed, or suggest by ***Turner***. Hence, claim 1 is allowable. Additionally, independent claims 11, 21, 31, 41, 51, and 61, which have similar elements that call for modeling the dependence of the deposition rate on the plasma power or deposition time based upon the target life, and using the model to modify the deposition processing to approach a desired thickness, are also allowable for at least the reasons cited above. Therefore, in light of at least the above-presented arguments, claims 11, 21, 31, 41, and 51 are also allowable.

Independent claims 1, 11, 21, 31, 41, 51, and 61, are allowable for at least the reasons cited above. Additionally, dependent claims 3-10, 12-20, 23-30, 32-40, 43-50, and 52-60, which

depend from independent claims 1, 11, 21, 31, 41, and 11, respectively, are also allowable for at least the reasons cited above.

B. Claims 3, 4, 7, 8, 13, 14, 17, 18, 23, 24, 27, 28, 33, 34, 37, 38, 43, 44, 47, 48, 53, 54, 57, 58, and 61 Are Not Unpatentable Over Turner in View of Sullivan

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, the prior art reference (or references when combined) must teach or suggest all the claim limitations. Second, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Third, there must be a reasonable expectation of success. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on Appellants' disclosure. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991); M.P.E.P. § 2142. Moreover, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 U.S.P.Q. 580 (CCPA 1974). If an independent claim is nonobvious under 35 U.S.C. § 103, then any claim depending therefrom is nonobvious. *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988); M.P.E.P. § 2143.03.

With respect to alleged obviousness, there must be something in the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination. *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561 (Fed. Cir. 1986). In fact, the absence of a suggestion to combine is dispositive in an obviousness determination. *Gambro Lundia AB v. Baxter Health-care Corp.*, 110 F.3d 1573 (Fed. Cir. 1997). The mere fact that the prior art can be combined or modified does not make the resultant combination obvious unless the prior art also suggests the

desirability of the combination. *In re Mills*, 916 F.2d 680, 16 U.S.P.Q.2d 1430 (Fed. Cir. 1990); M.P.E.P. § 2143.01. The consistent criterion for determining obviousness is whether the prior art would have suggested to one of ordinary skill in the art that the process should be carried out and would have a reasonable likelihood of success, viewed in the light of the prior art. Both the suggestion and the expectation of success must be founded in the prior art, not in the Appellants' disclosure. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991; *In re O'Farrell*, 853 F.2d 894 (Fed. Cir. 1988); M.P.E.P. § 2142. The Examiner does not establish a *prima facie* case of obviousness of the claims 3, 4, 7, 8, 13, 14, 17, 18, 23, 24, 27, 28, 33, 34, 37, 38, 43, 44, 47, 48, 53, 54, 57, 58, and 61, at least because the prior art references (***Turner*** and ***Sullivan***) when combined does not teach or suggest all the claim limitations of claims. Accordingly, the Examiner did not meet the legal standards to reject the claims , 4, 7, 8, 13, 14, 17, 18, 23, 24, 27, 28, 33, 34, 37, 38, 43, 44, 47, 48, 53, 54, 57, 58, and 61 under 35 U.S.C. § 103(a).

The combination of ***Turner*** and ***Sullivan*** does not disclose, suggest, or make obvious all of the elements of claims 3, 4, 7, 8, 13, 14, 17, 18, 23, 24, 27, 28, 33, 34, 37, 38, 43, 44, 47, 48, 53, 54, 57, 58, and 61. The Examiner stated that the elements relating to the dependence of the deposition rate on the deposition time or inverting the deposition rate model to determine the deposition time is not disclosed by ***Turner,*** and uses ***Sullivan*** to provide such elements. However, as described above, ***Turner*** does not disclose methods and/or apparatus for modeling the dependence of the deposition rate on the plasma power or deposition time based upon the target life, and using the model to modify the deposition processing to approach a desired thickness, which are called for by claims 3, 4, 7, 8, 13, 14, 17, 18, 23, 24, 27, 28, 33, 34, 37, 38, 43, 44, 47, 48, 53, 54, 57, 58, and 61 by virtue of their respective dependencies. Therefore, adding the disclosure from ***Sullivan*** would not make-up the deficit of ***Turner***.

Sullivan discloses a multi-layer sputtering method in which a controller calculates a sputtering time required for the deposition of a specified layer thickness (see col. 7, lines 54-57). ***Sullivan*** discloses a theoretical model that models deposited layer. However, ***Sullivan*** does not disclose modeling the dependence of deposition rate to deposition time. ***Sullivan*** adjusts the layer thickness in the theoretical model (see col. 7, lines 65-67). The Examiner states that the fact that determining a deposition time requires a certain deposition rate equates to modeling a dependence of deposition rate on the deposition time. Appellants respectfully disagree. No evidence or argument that would support such a conclusion is provided. ***Sullivan*** is directed towards calculating sputtering time for deposition of specified layer thickness, deposition rates are not calculated in this context. Additionally, ***Sullivan*** does not disclose inverting the deposition rate model to determine the deposition time to reach a deposition rate. Therefore, for at least the reasons cited above, adding the disclosure of ***Sullivan*** to the disclosure of ***Turner***, would not provide all of the elements of claims 3, 4, 7, 8, 13, 14, 17, 18, 23, 24, 27, 28, 33, 34, 37, 38, 43, 44, 47, 48, 53, 54, 57, 58 and 61. Therefore, in light of at least the above presented arguments, claims 3, 4, 7, 8, 13, 14, 17, 18, 23, 24, 27, 28, 33, 34, 37, 38, 43, 44, 47, 48, 53, 54, 57, 58 and 61 are allowable.

C. Claims 9, 10, 19, 20, 29, 30, 39, 40, 49, 50, 59, and 60 Are Not Unpatentable Over Turner in View of Claims 1, 2, 11, 12, 21, 22, 31, 32, 41, 42, 51, and 52.

As described above, in order to establish a *prima facie* case of obviousness, three basic criteria must be met. First, the prior art reference (or references when combined) must teach or suggest all the claim limitations. Second, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Third, there must be a reasonable

expectation of success. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on Appellants' disclosure. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991); M.P.E.P. § 2142.

Appellants respectfully assert that the Examiner did not meet the legal standards to reject the claims of the present invention under 35 U.S.C. § 103(a), including because of the fact that the prior art reference (***Turner***) does not teach or suggest all the claim limitations of the claims 9, 10, 19, 20, 29, 30, 39, 40, 49, 50, 59, and 60 of the present invention. The prior art reference (***Turner***) does not teach or suggest all the claim limitations of claims 9, 10, 19, 20, 29, 30, 39, 40, 49, 50, 59, and 60. Additionally, the Examiner provided no evidence to support a contention of some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference. Therefore, the Examiner does not establish a *prima facie* case of obviousness of the claims 9, 10, 19, 20, 29, 30, 39, 40, 49, 50, 59, and 60 of the present invention.

In light of the arguments provided herein, Appellants respectfully asserts that ***Turner*** does not disclose methods and/or apparatus for modeling the dependence of the deposition rate on the plasma power or deposition time based upon the target life using deposition sensor rate data, and using the model to modify the deposition processing to approach a desired thickness, which are called for by claims 9, 10, 19, 20, 29, 30, 39, 40, 49, 50, 59, and 60. The Examiner uses obviousness arguments to provide the element of modeling deposition rate and power using curve-fitting techniques. However, Appellants respectfully asserts that the Examiner does not provide any evidence to support such an assertion. Furthermore, even if, *arguendo*, the element

of modeling deposition rate and power using curve-fitting techniques were added to the disclosure of ***Turner***, the deficit of ***Turner*** would not be compensated for since ***Turner*** does not disclose modeling the dependence of the deposition rate on the plasma power or deposition time based upon the target life using the deposition sensor rate data, and using the model to modify the deposition processing to approach a desired thickness, which are called for by claims 9, 10, 19, 20, 29, 30, 39, 40, 49, 50, 59, and 60. Therefore, claims modeling the dependence of the deposition rate on the plasma power or the deposition time based upon the target life using deposition sensor rate data, and using the model to modify the deposition processing to approach a desired thickness, which are called for by claims 9, 10, 19, 20, 29, 30, 39, 40, 49, 50, 59, and 60 are allowable for at least the reasons cited above.

IX. CONCLUSION

In view of the foregoing, it is respectfully submitted that the Examiner erred in not allowing all claims pending in the present application, claims 1-25, over the prior art of record. The undersigned attorney may be contacted at (713) 934-4069 with respect to any questions, comments or suggestions relating to this appeal.

Respectfully submitted,

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APPENDIX A

1. (Previously presented) A method comprising:

monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target;

modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time, modeling said dependence of the deposition rate being based upon a target life of the sputter target, modeling said dependence of the deposition rate comprising using deposition rate sensor data for performing said modeling; and

applying the deposition rate model to modify the metal deposition processing to form the metal layer to approach a desired thickness.

2. (Canceled) The method of claim 1, wherein monitoring the consumption of the sputter target to determine the deposition rate of the metal layer during the metal deposition processing comprises modeling a dependence of the deposition rate on a target life of the sputter target.

3. (Original) The method of claim 1, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises modeling the dependence of the deposition rate on both the deposition plasma power and the deposition time.

4. (Original) The method of claim 2, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises modeling the dependence of the deposition rate on both the deposition plasma power and the deposition time.

5. (Original) The method of claim 1, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

6. (Original) The method of claim 2, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

7. (Original) The method of claim 3, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

8. (Original) The method of claim 4, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to

determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

9. (Original) The method of claim 1, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises fitting previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

10. (Original) The method of claim 2, wherein modeling the dependence of the deposition rate on the target life of the sputter target comprises fitting previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

11. (Previously presented) A computer readable, program storage device, encoded with instructions that, when executed by a computer, perform a method comprising:

monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target;

modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time, modeling said dependence of the deposition rate being based

upon a target life of the sputter target, modeling said dependence of the deposition rate comprising using deposition rate sensor data for performing said modeling; and

applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness.

12. (Canceled) The device of claim 11, wherein monitoring the consumption of the sputter target to determine the deposition rate of the metal layer during the metal deposition processing comprises modeling a dependence of the deposition rate on a target life of the sputter target.

13. (Original) The device of claim 11, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises modeling the dependence of the deposition rate on both the deposition plasma power and the deposition time.

14. (Original) The device of claim 12, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises modeling the dependence of the deposition rate on both the deposition plasma power and the deposition time.

15. (Original) The device of claim 11, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to

determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

16. (Original) The device of claim 12, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

17. (Original) The device of claim 13, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

18. (Original) The device of claim 14, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

19. (Original) The device of claim 11, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises fitting previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial

least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

20. (Original) The device of claim 12, wherein modeling the dependence of the deposition rate on the target life of the sputter target comprises fitting previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

21. (Previously presented) A computer programmed to perform a method comprising:

monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target;

modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time, modeling said dependence of the deposition rate being based upon a target life of the sputter target, modeling said dependence of the deposition rate comprising using deposition rate sensor data for performing said modeling; and

applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness.

22. (Canceled) The computer of claim 21, wherein monitoring the consumption of the sputter target to determine the deposition rate of the metal layer during the metal deposition processing comprises modeling a dependence of the deposition rate on a target life of the sputter target.

23. (Original) The computer of claim 21, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises modeling the dependence of the deposition rate on both the deposition plasma power and the deposition time.

24. (Original) The computer of claim 22, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises modeling the dependence of the deposition rate on both the deposition plasma power and the deposition time.

25. (Original) The computer of claim 21, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

26. (Original) The computer of claim 22, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to

determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

27. (Original) The computer of claim 23, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

28. (Original) The computer of claim 24, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

29. (Original) The computer of claim 21, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises fitting previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

30. (Original) The computer of claim 22, wherein modeling the dependence of the deposition rate on the target life of the sputter target comprises fitting previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting,

polynomial least squares fitting, non polynomial least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

31. (Previously presented) A method comprising:

monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target by modeling a dependence of the deposition rate on a target life of the sputter target;

modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time, modeling said dependence of the deposition rate comprising using deposition rate sensor data for performing said modeling; and

applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness.

32. (Original) The method of claim 31, wherein modeling the dependence of the deposition rate on the target life of the sputter target comprises modeling the dependence of the deposition rate on target lives of a plurality of previously processed sputter targets.

33. (Original) The method of claim 31, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises modeling the dependence of the deposition rate on both the deposition plasma power and the deposition time.

34. (Original) The method of claim 32, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises modeling the dependence of the deposition rate on both the deposition plasma power and the deposition time.

35. (Original) The method of claim 31, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

36. (Original) The method of claim 32, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

37. (Original) The method of claim 33, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

38. (Original) The method of claim 34, wherein applying the deposition rate model to modify the metal deposition processing comprises inverting the deposition rate model to

determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

39. (Original) The method of claim 31, wherein modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises fitting previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

40. (Original) The method of claim 32, wherein modeling the dependence of the deposition rate on the target lives of the plurality of previously processed sputter targets comprises fitting previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

41. (Previously presented) A system comprising:

a tool monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target;

a computer modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time, modeling said dependence of the deposition rate being based upon a target life of the sputter target, modeling said dependence

of the deposition rate comprising using deposition rate sensor data for performing said modeling; and

a controller applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness.

42. (Canceled) The system of claim 41, wherein the tool monitoring the consumption of the sputter target to determine the deposition rate of the metal layer during the metal deposition processing models a dependence of the deposition rate on a target life of the sputter target.

43. (Original) The system of claim 41, wherein the computer modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time models the dependence of the deposition rate on both the deposition plasma power and the deposition time.

44. (Original) The system of claim 42, wherein the computer modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time models the dependence of the deposition rate on both the deposition plasma power and the deposition time.

45. (Original) The system of claim 41, wherein the controller applying the deposition rate model to modify the metal deposition processing inverts the deposition rate model to

determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

46. (Original) The system of claim 42, wherein the controller applying the deposition rate model to modify the metal deposition processing inverts the deposition rate model to determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

47. (Original) The system of claim 43, wherein the controller applying the deposition rate model to modify the metal deposition processing inverts the deposition rate model to determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

48. (Original) The system of claim 44, wherein the controller applying the deposition rate model to modify the metal deposition processing inverts the deposition rate model to determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

49. (Original) The system of claim 41, wherein the computer modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time fits previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial

least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

50. (Original) The system of claim 42, wherein the tool modeling the dependence of the deposition rate on the target life of the sputter target fits previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

51. (Previously presented) A device comprising:

means for monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target;

means for modeling a dependence of the deposition rate on at least one of deposition plasma power and deposition time, modeling said dependence of the deposition rate being based upon a target life of the sputter target, said means for modeling comprising means for modeling said dependence of the deposition rate comprising using deposition rate sensor data for performing said modeling; and

means for applying the deposition rate model to modify the metal deposition processing to form the metal layer to have a desired thickness.

52. (Original) The device of claim 51, wherein the means for monitoring the consumption of the sputter target to determine the deposition rate of the metal layer during the

metal deposition processing comprises means for modeling a dependence of the deposition rate on a target life of the sputter target.

53. (Original) The device of claim 51, wherein the means for modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises means for modeling the dependence of the deposition rate on both the deposition plasma power and the deposition time.

54. (Original) The device of claim 52, wherein the means for modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises means for modeling the dependence of the deposition rate on both the deposition plasma power and the deposition time.

55. (Original) The device of claim 51, wherein the means for applying the deposition rate model to modify the metal deposition processing comprises means for inverting the deposition rate model to determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

56. (Original) The device of claim 52, wherein the means for applying the deposition rate model to modify the metal deposition processing comprises means for inverting the deposition rate model to determine the at least one of the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

57. (Original) The device of claim 53, wherein the means for applying the deposition rate model to modify the metal deposition processing comprises means for inverting the deposition rate model to determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

58. (Original) The device of claim 54, wherein the means for applying the deposition rate model to modify the metal deposition processing comprises means for inverting the deposition rate model to determine the deposition plasma power and the deposition time to form the metal layer to have the desired thickness.

59. (Original) The device of claim 51, wherein the means for modeling the dependence of the deposition rate on the at least one of the deposition plasma power and the deposition time comprises means for fitting previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

60. (Original) The device of claim 52, wherein the means for modeling the dependence of the deposition rate on the target life of the sputter target comprises means for fitting previously collected metal deposition processing data using at least one of polynomial curve fitting, least squares fitting, polynomial least squares fitting, non polynomial least squares fitting, weighted least squares fitting, weighted polynomial least squares fitting, and weighted non polynomial least squares fitting.

61. (Previously presented) A method comprising:

monitoring consumption of a sputter target to determine a deposition rate of a metal layer during metal deposition processing using the sputter target;

modeling a dependence of the deposition rate based upon a deposition plasma power and a deposition time, modeling said dependence of the deposition rate being based upon a target life of the sputter target, modeling said dependence of the deposition rate comprising using deposition rate sensor data for performing said modeling, said modeling comprising monitoring the consumption of sputter target; and

applying the deposition rate model to modify the metal deposition processing to form the metal layer to approach a predetermined thickness.